Description

A METHOD AND APPARATUS FOR AGGREGATING INCOMING PACKETS INTO OPTICAL

BURSTS FOR AN OPTICAL BURST SWITCHED NETWORK

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In Optical Burst-Switched networks, or so called OBS net-
works, packets, e.g. Internet Protocol (IP) packets, Asyn-
chrony Transfer Mode (ATM) cells or protocol data units
10 (PDUs), are aggregated into optical bursts in order to be
transferred through the OBS network or respective optical
network. The conversion of packets into optical bursts takes
place in the edge nodes of an OBS network according to a cer-
tain aggregation strategy. The solutions so far provide two
15 main aggregation strategies: the aggregation strategy with
timeouts and the aggregation strategy with a buffer limit.

First we will discuss the aggregation strategy with timeouts.
A schematic example is shown in Figure 1. In this scheme,
20 packets 102 are added or padded to the burst 104 which is be-
ing generated in a buffer 106 until a certain timer T ex-
pires. Then the burst 108 is sent.

The second, Aggregation strategy with buffer limit will be
25 discussed with reference to Figure 2. In this scheme, packets
202 are added or padded to the burst 204 which is being gen-
erated in a buffer 206 until the buffer is full. Then the
burst 208 is sent.

30 Once the packets are transformed into bursts and sent into
the OBS network, they travel in the OBS network through a se-
ries of optical switches to a certain destination. At best,
these optical switches have limited storage capabilities,
e.g. fiber delay lines, and at worst, no storage capabilities
35 at all in the normal case. Therefore, collisions among opti-
cal bursts occur. Major performance parameters of an OBS net-

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work are thus the burst blocking probability, the throughput
and the delay.

The two main aggregation strategies timeout and buffer limit
5   have the disadvantage of a certain blocking probability and
maximum achievable throughput.

It is an object of the invention to reduce the blocking prob-
ability and increase the throughput of an OBS network.
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This object is achieved by the features recited in claim 1, 4
and 8.

The novel inventive aggregation strategy is based on the fol-
15   lowing widely accepted assumption for highly multiplexed
traffic (core networks): the packet arrival rate process is
determined according to a Poisson distribution. With this as-
sumption, the idea is to consider the random selection prop-
erty of any Poisson process, in order to obtain a Poisson
20   process of a lower arrival rate.

This lower-rate Poisson process will mark the beginning of a
new optical burst or the end of an optical burst. So it is
possible to assure that the burst send and arrival process is
25   Poisson. In addition, the inter-arrival times between bursts
will be negative-exponential distributed, as the inter-
arrival times of any Poisson process.

It shall be appreciated that advantages of the invention are:
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• A lower blocking probability in the optical switches is
   provided, as compared to the standard aggregation strate-
   gies.
• Predictability of the blocking probability. The blocking
35   probability can be calculated with the Erlang-B formula.
   Whereas for the other aggregation strategies no analytical
   formula is known.

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- Due to the lower blocking probability a higher throughput in optical switches of the OBS network is achieved.
- Predictability of the throughput. The throughput, unlike with the prior art strategies, can be calculated with the help of the Erlang B formula.
- It is easier to calculate waiting times for bursts and/or headers of bursts.
- A lower waiting time for the optical headers in the optical switches.
- In the case burst buffering is available, e.g. by the use of fiber delay lines, a lower waiting time for bursts in the optical switch is achieved.

Further developments of the invention are identified in subclaims.

An exemplary embodiment of the invention is described in greater detail below with reference to a drawing.

Shown in the drawing are:

FIG 1 the initially cited prior art.

FIG 2 the initially cited prior art.

FIG 3 an schematically example for the aggregation and random selection process.

FIG 4 a graph with the blocking probability as a function of the load for different aggregation strategies.

Figure 3 shows two associated timelines P and B. On the first timeline P packets PA, pictured as arrow line, are received in chronological order, e.g. IP packets, ATM cells or PDUs. Every packet is associated with a generated random binary digit. A binary digit has a first and a second value, e.g. 1 for the first value and 0 for the second value or opposite.

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So, every packet is associated either with a 1 or a 0. The random binary digits can be generated by a Bernoulli random generator, according to a Bernoulli probability distribution. The probability for every value of the random binary digit, thus the probability (p) for the 1's and (1-p) for the 0's, is determined by a certain probability distribution, e.g. $p(1)=0,01$ and $p(0)=0,99$. These packets are aggregated in a buffer to accumulate an optical burst. A packet with an associated first value, e.g. with a 1 indicates a transition between optical bursts, e.g. the beginning of a new burst. In figure 3 this is labeled with BA. The chronological last packet with a 0 before a packet with a 1, is the last packet of the burst, marked with LPB in figure 3. On the second timeline B in figure 3 the resulting Bursts B1, B2 and B3 are shown. The time difference Z between the beginning of two successive bursts is called inter-arrival time. The aggregation delay is the delay experienced by a packet in the edge node until the burst to which it belongs is completed. After appearance of a packet with a 1, a new burst begins and the old burst is send into the OBS network.

The used probability distribution determines the average number of packets per burst. E.g. the average number of packets per burst is equal to $1/p(1)$. For the example, if $p(1)=0,01$, the average number of packets per burst is $1/p(1)=100$ packets per burst.

The method can also be realized, that the second value indicates a transition between optical bursts.

Also the first value indicates, instead of the beginning of a new burst, the end of the aggregated packets and by that the end of the aggregated burst. The main idea is, that a generated random digit with a certain probability indicates the beginning or the end of a burst, which consists of aggregated packets, e.g. IP packets.

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The invention can be implemented by the following steps/algorithm:

- Every time the edge node receives a packet, e.g. an IP
  packet, it sends it to the buffer.
- Then the edge node reads the generated associated random
  binary digit / random number corresponding to the next
  packet.
- If the associated random binary digit / random number for
  the next packet is a first value, e.g. a 1, the accumu-
  lated burst in the buffer is sent.
- Otherwise, do nothing.

A simulation has been done with Matlab® in order to calculate
the blocking probability in an optical switch with no wave-
length conversion available as a function of the load. The
results are presented in figure 4. In figure 4 AT means ag-
gregation strategy with aggregation timer, AB means aggrega-
tion strategy with aggregation buffer, Erl B means theoreti-
cally possible load according to Erlang B formula and RS
means inventive aggregation strategy with random selection.

It can be observed that the inventive random selection strat-
egy leads to the lowest blocking probability and furthermore
it matches the Erlang-B formula predictions.